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July-August, 1961

NEWS AND TRENDS . . .

IN CITY DEVELOPMENT

PUBLISHED BY URBAN LAND INSTITUTE

BUILDING TRAFFIC SAFETY INTO RESIDENTIAL DEVELOPMENTS

A New Edition

(See Editorial, Page 2)

INTRODUCTION
(To Original Edition)

The provision of attractive homes in residential subdivisions, where families can live comfortably and with the privacy, beauty and repose sought by most home owners, is not incompatible with high standards of traffic safety. On the contrary, the absence of traffic hazards and inconveniences will enhance these qualities of "livability" and so improve property values.

A high percentage of present home sites in cities were laid out long before the automobile became a permanent part of American life. The results often have been unfortunate. Traffic volumes, noises and casualties have mounted, expensive corrective measures have been tried, and many homes have been made undesirable for residential use. There is no assurance that homes in new subdivisions will retain their proper values in a motor age unless sound traffic safety principles are "built in."

Most effective results can be obtained only through proper original layout and design. True, certain corrections can be made after the residential area has been developed and lived in, but measures taken then are generally either expensive or are only palliatives which produce, at best, ineffective traffic results. A high proportion of residential areas, many containing fine and valuable homes, are at present unduly hazardous and inconvenient from the traffic standpoint. The application of traffic engineering techniques has often produced considerable improvement, but it has not been possible to overcome bad original design.

This manual has been prepared, not as a set of standards, but as a guide for use by developers, subdividers, platting officials and planners to help them provide, from the traffic standpoint, safer and more desirable residential subdivisions. The authors have tried to fit the traffic recommendations into good subdivision design, but they have not compromised on desirable and appropriate traffic features in order to do so.

The production of this manual has been under the sponsorship of the National Committee for Traffic Safety. Preparation has been by a special technical committee.

The combined judgments of members of the special committee are represented in this manual. As would be expected, there were more than minor differences of viewpoint on a few matters. As to several of these, the text notes the differing viewpoints. Where only a few differed, the majority viewpoint is presented, and hence a few members are not in accord with one or two parts of the report.

A library research of writings on the subject was made originally by Alfred Edwards of the School of Architecture and Planning of the Massachusetts Institute of Technology. Robert S. Holmes, now Executive Secretary of the Institute of Traffic Engineers, prepared summaries and excerpted useful material from Mr. Edwards' references. The first draft of the manual was prepared by John J. Dobelek, Detroit Traffic Engineering Bureau, and Frank C. Eisenach, Michigan State Highway Department. Extensive revisions and final drafting were completed by an informal editing committee consisting of Richard Ives, Federal Housing Administration; LeVerne Johnson, American Automobile Association; Burton W. Marsh, American Automobile Association; D. Grant Mickle, Automotive Safety Foundation; O. K. Normann, Bureau of Public Roads; and Max S. Wehrly, Urban Land Institute.

John W. Gibbons, Automotive Safety Foundation, reviewed the material and made valuable suggestions for simplifying and clarifying technical phraseology.

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Plan-itorial . . .

Traffic-Safe Neighborhoods

Occasionally a particularly useful, significant and basic publication appears that is in danger of being lost sight of through passage of time, depletion of copies, or the course of events. Such a publication is a 40-page booklet entitled **Building Traffic Safety Into Residential Developments,** published in the late 1940's under the auspices of the National Committee for Traffic Safety and republished, in part, in this issue of *Urban Land*. It was the first study of its kind and, in our opinion, it still is the best reference on a subject which has received much too little attention.

Depletion of the publication, together with a continuing demand for the information it contained, prompted us to suggest reprinting major portions of the study to Burton W. Marsh of the American Automobile Association and D. Grant Mickle of the Automotive Safety Foundation, who represented two of the principal sponsors of the original study. The suggestion met with their immediate approval.

In addition to the above organizations, the original study had the cooperation of the American Municipal Association; American National Red Cross; Association of Casualty and Surety Companies; National Association of Home Builders; National Safety Council; and Urban Land Institute.

The document was developed by a technical committee headed by Mr. Marsh. The committee representatives were drawn from local, state, and Federal planning, highway, and housing agencies; professional societies, universities, and civic organizations as well as those agencies specifically mentioned. Field tests on items such as roadway widths were conducted by the Bureau of Public Roads.

While certain refinements have occurred since the original publication was issued, the principles and standards relating to the major portion of the document remain relatively unchanged. Where substantial changes have occurred an editor's note has been inserted in the version reproduced here. Minor outdated sections relating to street lighting, street names, shopping centers, utilities, and play areas have been omitted. This, in our opinion, in no way impairs the usefulness of the bulk of the report to land developers, designers, highway engineers and planners in refreshing their memory on basic factors in developing sound and SAFE residential neighborhoods.

We would like to comment on the continuing importance of this document as it applies to community design and development. Almost without exception the findings and recommendations reinforce desirable trends in residential community design developed in the decade or so since the study first appeared. Documenting many of these recommendations is Harold Marks' detailed study, "Subdividing for Traffic Safety," which appeared in the October 1957 issue of *Urban Land*. Mr. Marks lists the following elements of safe design in residential subdivisions:

1. Limited access design, preferably limited to quarter-mile access points, appears to provide maximum safety.
2. Backup, side-on or cul-de-sac treatment is generally preferable to a service road contiguous to major highways.
3. Continuous through-streets extending from one major street to another should be avoided.
4. Collector streets are satisfactory when there are no continuous cross streets and if they exit into only one major street.
5. Four-legged intersections should be used infrequently, although they are not objectionable where non-continuous access streets join the collector street.
6. T-type intersections should be used more frequently.
7. Such design features as multi-legged intersections with more than four legs, acute angle and Y-type intersections, and jog intersections should be avoided.

A further reinforcement of these principles will be found in the recent study on new approaches to residential development* in which the search for increased livability, and better land use, efficiency, and more usable open space areas incorporate and adapt traffic safety features into contemporary residential community layout.

M.S.W.

* *New Approaches to Residential Land Development*, T.B. 40, URBAN LAND INSTITUTE, 1961.

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CLARENCE TURLEY HONORED

Clarence M. Turley, Trustee and First Vice President of ULI, was elected President of Civic Progress Inc. of St. Louis, in June, succeeding David R. Calhoun, Jr., President of the St. Louis Union Trust Company.

Mr. Turley, who is also Chairman of the Institute's Central Business District Council, has been a member of Civic Progress since its organization in 1953. Civic Progress is comparable to the Allegheny Conference of Pittsburgh in its activities and objectives, and since its founding has been a major factor in stimulating the revitalization of the St. Louis area.

Other Civic Progress officers elected were: August A. Busch, Chairman; Donald Danforth, Vice Chairman; Clark R. Gamble and Henry H. Rand, Vice Presidents; William A. McDonnell, Treasurer, and Ethan A. H. Shepley, Secretary.

CONTENTS AND SUMMARY

Location and Design of Development

Should be in harmony with major street plan of community.

Should be accessible to main highway—but access controlled.

Practical minimum distance between intersections on main highway—800 feet.

Assuming not over 40 vehicles per 100 family units move during the peak hours, a roadway with one lane in each direction will provide for 750 family units.

A minimum number of cross streets is desirable, consistent with circulation needs.

Design of Local Residential Streets

Speed: Based on maximum of 25 m.p.h. in accord with Uniform Vehicle Code recommendation. Recommendations will be reasonably satisfactory even if some speeds exceed 25 m.p.h. a little.

	Single-family	Multi-family
Street Width:	50 feet	60 feet
Pavement Width:	26 feet	32 feet
Curbs:	Straight curb recommended	Same
Sidewalks:		
Width:	4 feet minimum	Same
Set-back:	3 feet minimum if no trees, 7 feet minimum with trees	Same
Horizontal Alignment.	200 feet minimum sight distance	Same
Vertical Alignment:	6-8 per cent maximum grade desirable; 3-4 per cent per 100 feet maximum rate of change	Same
Cul-de-sac:	400-500 feet maximum length	Same
Turn-arounds:	40 feet minimum curb radius without parking	Same
	50 feet minimum curb radius with parking	Same
Pavement Surface:	Non-skid with strength to carry traffic load	Same

Design of Feeder Streets

Street Width:	60 feet
Pavement Width:	36 feet
Curbs:	Straight curb recommended
Sidewalks:	
Width:	4 feet minimum
Set-back:	3 feet minimum if no trees, 7 feet minimum with trees
Horizontal Alignment:	Same as for local residential streets
Vertical Alignment:	Same as for local residential streets
Pavement Surface:	Same as for local residential streets

Intersection Design

Sight Distance:	Such that each vehicle is visible to the other driver when each is 75 feet from the intersection, for 25 m.p.h. maximum speed.
	No building or other sight obstruction within sight triangle.
Vertical Alignment:	Flat grade within intersection.
	Flat section preferred from 50 feet to 100 feet each way from intersection, but in no case over 3-5 per cent grade.
	6 per cent maximum between 100 and 150 feet of intersection.
Horizontal Alignment:	90 degree intersections preferred; less than 60 degrees unduly hazardous.
	Curb radius for local and feeder streets—12 feet.
	Curb radius for feeder street intersecting main highway—50 feet.

Sidewalks

Placement:	Set-back should be minimum of 7 feet where trees are planted between curb and sidewalk; minimum of 3 feet if no trees.
Width:	4 feet minimum (4½-5 feet minimum near shopping centers).

Parking in Residential Areas

Ample off-street facilities should be provided.

Private garage or space, with private driveway, should be provided for single and semi-detached dwellings.

Parking bays not physically divided from roadway may be used on strictly local streets with little traffic. Requires 180 to 210 square feet per car.

Parking bays physically divided from roadway preferred on streets carrying more than local traffic, such as feeder streets. Requires approximately 360 square feet per car, including service aisles and divider.

Parking lot is most desirable off-street facility. Requires 275-300 square feet per car, including aisles.

Alleys

Not considered necessary or desirable in single-family developments.

May be necessary in group, row house or apartment developments.

If provided should be 20 feet wide and paved.

Curb Cuts for Driveways

Curb return with radius of 3 to 5 feet desired. 7-foot radius desirable at parking lot entrances.

BUILDING TRAFFIC SAFETY INTO RESIDENTIAL DEVELOPMENTS

LOCATION AND DESIGN OF DEVELOPMENT

In the planning and design of any new residential area, whether it be one street or an entire neighborhood, there are numerous traffic safety features which the developer should consider. The traffic safety principles set forth herein are applicable to any location and to any size development—from one home to an entire community.

When built and occupied, the development becomes a functioning integral part of the city, town or county in which it is located. The homes and the services in the development will function only as well as they fit into the community's life and growth. In locating and planning the project, the developer will be wise to examine the place it will have in the community. Where there is a city or county planning organization, he should secure its assistance in the consideration of these matters, including among specific subjects, access to main highways, street layout and design, pedestrian and vehicular traffic requirements, parking facilities, shopping centers, recreation areas, and public utilities and services.

If the development is located in a community which has an officially adopted major street plan, the design of the project will have to fit into that plan. It will also be required to comply with any zoning and subdivision regulations which are in force. An understanding of the capacity of the existing and proposed street system and the densities of population likely to occur (which zoning regulations determine) will give the developer a sound basis on which to estimate the traffic and safety requirements of his development, because he will know how much and what kind of traffic can be expected to use the various streets in his development.

Outlined below are the major traffic safety features which the developer should take into account.

Location Considerations

(1) Accessibility to a main highway.[1]
(2) Suitability of the site topography to avoid unduly steep street grades.
(3) Requirements of zoning ordinance.
(4) Availability of public transportation or possibility of arranging for such transportation within one-quarter mile walking distance.
(5) Location of existing or proposed shopping centers and schools so that they may be reached without crossing main highways wherever possible.
(6) Possibility that adjacent areas may be developed.

Design Considerations

(1) Compliance with subdivision regulations.
(2) Minimum number of intersections with the main highways. Underpasses and overpasses for vehicles and pedestrians.
(3) Land separation strips between main highway and subdivision properties.
(4) Development of new shopping areas on the same side of a main highway as residential areas to be served.
(5) Control of ingress and egress to shopping or business areas from major traffic arteries.
(6) Designing into streets those features set forth in the following pages which provide for traffic safety.

Access to Main Highway

From a traffic safety point of view, access points to a main highway should be limited in number and should have special design treatment. Intersections of main highways are points of traffic conflict and accident hazard. The fewer there are, consistent with all other requirements, the fewer accidents there will be. In most cases 800 feet should be a practical **minimum** distance between intersections on a main highway. The distance will usually be much greater on a controlled-access highway. Uniform spacing between intersections is advantageous if traffic signals are to be used.

Every intersection on a main highway is a potential area of accidents, as well as a cause of delay. By keeping intersections few in number, accidents and delays will be minimized. For example, when it is necessary to control intersection traffic with signal lights, it is easier to coordinate the signals to provide progressive traffic movement when intersections are not too close together and when they are uniformly spaced.

Consideration should be given to the traffic which may be generated by other subdivisions which might later be developed in the same general area. The local planning agency should be consulted, and from the master street or road plan that agency will determine which streets of the new development will be expected to serve as feeder streets. This is important since traffic from such additional residential areas might have to pass over streets of the proposed development. Where such a

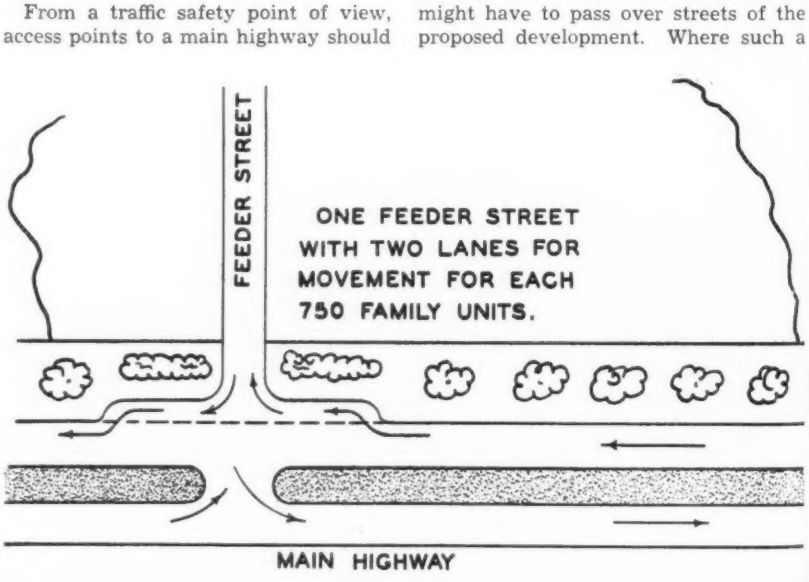

FIGURE 1.

Access points to main highways should be limited in number and have special treatment. (*While details have changed the principle remains sound—Ed.*)

[1] For the purpose of this discussion, "main highway" includes major arterial streets, expressways, secondary highways and other through trafficways.

condition is expected the streets will have to be designed to serve adequately all subdivisions in a reasonable tributary area. A good master street plan should provide useful information to determine what traffic the various feeder streets within the subdivision will ultimately be expected to carry. (See further discussion of feeder streets.) Such multiple use should be avoided when possible, however, for both residential desirability, and property values and public safety decline when traffic is routed through a residential area.

Traffic Generated by the Development

The interior street system is composed of the local residential streets and feeder streets and must be capable of handling the traffic generated by the development safely, efficiently and conveniently. In certain special cases, as pointed out above, some feeder streets may have to carry some traffic not generated within the immediate area, but good planning will avoid this condition insofar as possible.

In subdivisions there are essentially three types of street uses: (1) the local residential street of one-family houses on which drivers can be expected to weave in and out between occasional parked cars; (2) the street of multi-family houses of much the same character as the one-family street, but where the number of parked cars may be so great that weaving in and out would be impossible; and (3) the feeder street where people expect greater freedom of movement, where traffic volume is greater, and where weaving among even occasional parked cars should not be expected. The first two are referred to in this report as "local residential streets" but of different widths.

The developer should make a careful estimate of the probable traffic needs of the subdivision based upon complete occupancy and such factors as:

(1) Probable economic level of residents.
(2) Population density and distribution.
(3) Automobile ownership figures of existing similar subdivisions in the area.

Subdivision vehicular traffic will consist of:

(1) Vehicles driven by the residents.
(2) Service vehicles.
(3) Visitors' vehicles and casual traffic.

Because of the varying size of blocks in different sections of the country, no rule is offered to determine the safest distance between intersections. However, it will be necessary to collect traffic from local residential streets which do not give direct access to a main highway into feeder streets which do have such access. This may be done in a number of ways without any serious inconveniences. Some suggestions for such street system layouts are shown in Figure 2. (*The same principle can be applied to the more recent "cluster" type development. See "New Approaches to Residential Land Development," Technical Bulletin 40, Urban Land Institute, 1961. Ed.*)

FIGURE 2.
Typical layout showing local residential and collector streets.

It is reasonable to assume there will be one private automobile for each single-family unit in new subdivisions. Where density of land occupancy is less than ten persons per acre, walking distance from established transit service is over one-fourth mile and family income level is above average, greater use of private passenger cars is expected. Where these conditions prevail there may be [an average of] 1½ to 2 cars per family unit. A good basis for estimate would be a nearby established subdivision of similar character, if such exists.

The problem of providing proper traffic safety measures on feeder streets where traffic collects for access to main highways, and at intersections where such connecting streets enter main highways is most important. In some developments certain internal intersections may also require special design treatment. (See discussions of design of local residential and of feeder streets.)

An approximate analysis of the traffic needs of a subdivision can be based on the following:

(1) One traffic lane in a residential subdivision can be expected to handle about 300 vehicles per hour in one direction. Contrary to general belief, lane capacities are not nearly so high as on major arteries and expressways where there are virtually no interruptions. In subdivisions there is interference from occasional parked cars, pedestrians, vehicles using intersections, etc.

(2) Ordinarily most of the traffic in the peak hour will move in one direction—out of the subdivision in the morning and back in at night. If the need is for not more than 300 vehicles during such a peak hour, a total of two moving lanes, one in each direction, is sufficient. (See later discussion of parking lanes.)

(3) If on a feeder street, destinations are split so that traffic volumes in the peak hour are equal in two directions, two moving lanes—one in each direction—can handle up to 600 vehicles in that hour.

(4) If on a feeder street, traffic in either direction exceeds 300 vehicles in the peak hour it will be necessary to provide a street with four lanes for movement or a greater number of feeder streets with two lanes. Wherever possible the need for four moving lanes should be avoided in the design by provision of additional feeder streets, because the amount of traffic warranting four

moving lanes is generally objectionable on a residential street.

(5) If four moving lanes are required on a feeder street, a separator strip at least 20 feet wide is recommended. Such a center strip provides protection for pedestrians and increases safety for vehicular traffic. It aids vehicles making left turns or U turns.

What do these values mean to the developer in terms of family units? Here is an approximate basis for application:

Ordinarily not over 40 vehicles per 100 family units will move during the peak hour. Thus a roadway with a single moving lane in each direction having a capacity of 300 cars per lane per hour could provide for 750 family units. (This is derived by dividing 300 by 0.40.) This is a safe rule to follow in determining street needs.

Interior Street Plan

The "interior" street plan refers here to those streets within a residential development whose primary function is to provide access to abutting property and to collect and distribute local traffic within the development. They should be designed for these purposes. Such streets generally consist of two types: (1) the local residential street, and (2) the feeder street. The local street should serve mainly for access to abutting property and for circulation of traffic within the subdivision. The feeder street, while it usually provides access to abutting property and internal circulation, is also a collector and distributor for a number of local streets connecting the latter with a major traffic artery. Planning and proper design based on this classification of street arrangement minimizes many of the objectionable features of automobile traffic in residential neighborhoods and promotes public safety.

Interior subdivision streets need not be straight, wide, nor continuous for long distances. A right-of-way width of 50 feet with a 26-foot roadway is all that is necessary or desirable for local streets in single-family residential areas. Not being designed for fast traffic, close adherence of such streets to topographical conditions is possible and desirable. Loops, "U"-shaped streets, culs-de-sac, moderate curves and hills—all discourage speed and through traffic. For example, grades up to 8 per cent and 200 foot sight distances are acceptable.

A minimum number of intersections and cross streets consistent with adequate internal circulation should be an objective in the interest of public safety. Modern subdivision designers favor this idea. Block lengths up to 1200 to 1400 feet have been found satisfactory where the streets lead in the direction of the focal points of the development, such as the shopping center, school, and public transit stops. Pedestrian walkways should be provided across long blocks when streets do not lead directly to such focal points.

The cul-de-sac or dead-end street has the advantage of preventing through traffic movement. Such streets are useful where topography or exceptional block depths create odd-shaped land areas. Culs-de-sac should not exceed 400 to 500 feet in length. An adequate turn-around is essential. Longer cul-de-sac blocks make drivers go too far before reaching the turn-around. They are also disadvantageous because speeds can build up too high. For turning circles a minimum outer curb roadway radius of 40 feet is suitable, but 50 feet will be necessary if there is to be parking within the circle in order to provide space for turning such long vehicles as fuel trucks. "Back-arounds" or "T"-shaped culs-de-sac can be used satisfactorily where lengths do not exceed 300 to 350 feet and where population densities are low.

The "loop" street is preferable to the cul-de-sac as it provides easy circulation which is desirable for deliveries, fire and police protection, and if well designed, is effective in discouraging fast or through traffic.

Feeder streets have a dual function: (1) to serve as collectors and distributors between the major traffic artery at the edge of the development and the internal system of local streets; and (2) to act as access streets for abutting property. To serve these purposes,

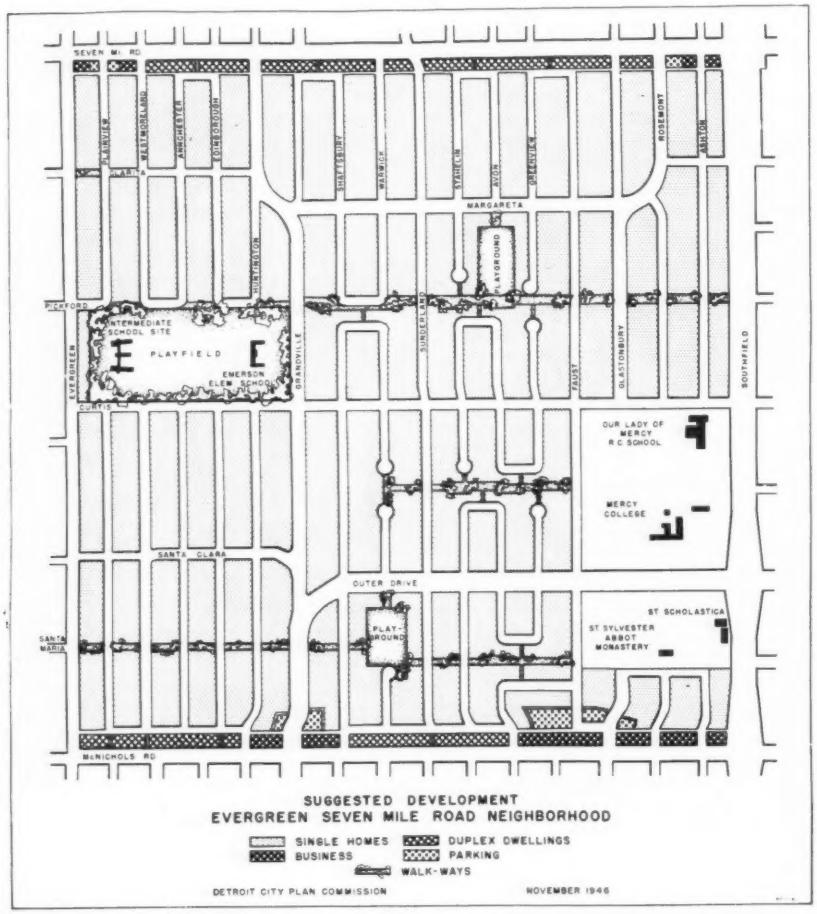

FIGURE 3.

This redesign of a Detroit neighborhood prevents traffic from going through the residential district except on Grandville and Curtis Streets. Sunderland, for example is blocked at McNichols Road by a row of duplex dwellings.

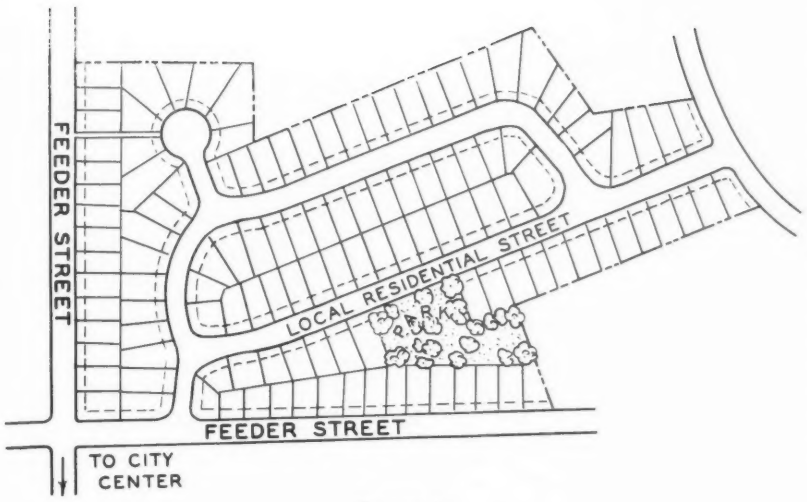

FIGURE 4.

An example of long blocks directionally oriented to function properly.

greater width and continuity are desirable. A 60-foot right-of-way with a 36-foot roadway is recommended. The feeder street should generally lead to or toward one or more focal points of the development. By its nature the feeder street will normally contain a relatively large number of intersections with local residential streets. This is to be desired if it is to function adequately as a collector. Thus, residential frontage requiring access will be less because the ends of blocks will normally abut the feeder street.

Intervals between feeder streets will, of course, vary with the type and density of development and the additional traffic, if any, which may at some future time originate in any extension of the original, or in an adjacent development. Because it is desirable to have as few intersections of feeder streets with the main highway as is consistent with good access to and circulation within the community, consideration should be given to combining feeder street outlets at or near the main highway. These will normally be the points near which the shopping center and transit stops will be found.

DESIGN OF LOCAL RESIDENTIAL STREETS

Local residential streets, as herein visualized, are purely local in character and are for the sole purpose of providing access to and egress from individual properties. **In a properly planned development local streets will carry no through traffic and will afford neither opportunity nor occasion for high speed driving.** The outmoded gridiron pattern with all streets of the same width and uniformly spaced should not be used.

Local residential street design (as well as other discussions in this publication) is based on a speed of 25 miles per hour as recommended in the Uniform Vehicle Code. (Act V, Article VI, Section 56 (b) 1, 1948 Edition.)

Local residential streets fall into two categories: (1) those in developments consisting of single-family detached and semi-detached dwellings, and (2) those in multiple housing developments. These two types of local residential streets have many design features in common, but other factors, notably curb parking requirements, are so different that the two classes of streets must be treated separately.

1. Local Residential Streets in Single-family Dwelling Development

a. **Cross-sectional design.** Between the property lines of lots facing a street lie the sidewalks, curbs, gutters, roadway surface, and in some instances special areas for planting and for automobile parking. The cross-section of these elements taken together comprises the cross-section of the street. Each element will be discussed in turn.

Pavement Width: Off-street parking facilities are highly desirable, for reasons outlined under PARKING IN RESIDENTIAL AREAS. It is assumed that in the type of development under discussion such facilities will be provided on individual properties. Regardless of the adequacy and convenience of off-street facilities, however, occasional standing or parking within the roadway must be expected and some allowance must be made for it in the design of the roadway. A 26-foot paved surface is recommended for these conditions. If no off-street parking were provided, this recommended width would be insufficient, but with only an occasional vehicle standing in the roadway, two directional traffic may be maintained with little driver inconvenience. With more than 26-foot width the street might attract undesirable non-local traffic. If the roadway width is less than 26 feet, traffic might be unduly interfered with by two vehicles carelessly parked opposite each other. Moreover, with less than a 26-foot roadway a car cannot back out of a private driveway in one maneuver when a car is parked opposite.

Curbs and Sidewalks: In developed areas curbs are usually necessary to control storm-water run-off, and in most localities a curb height of about six inches is required. Either a straight curb or a roll-type curb has been used. The roll curb and gutter have some advantages in economy, as for example in obviating the necessity for curb cuts and curb returns at driveways. Disadvantages of the roll curb include difficulty in crossing by a car particularly when streets are icy. If roll curb is used on local residential streets it is recommended that the combination curb and gutter be two feet wide, and that it be rolled on a 17-inch radius.

The principal advantage of the straight curb is that by its use, driving and parking areas are defined more effec-

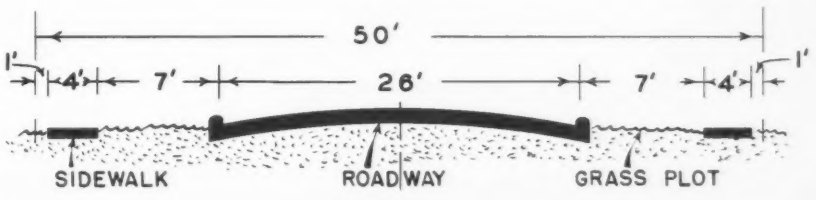

FIGURE 5.

A typical cross-section of a local residential street

tively than by any other type curb. It constitutes more of a barrier to a vehicle out of control than a rounded roll curb. Children are less likely to ride wheeled vehicles into roadways having straight curbs of recommended 6-inch height. Straight curbs are recommended at all intersections, whether or not they are used elsewhere.

Conventionally, it has been the practice to reserve a planting strip between the curb and sidewalk for grass and shade trees. Such a strip also gives a margin of safety, or at least a feeling of security to pedestrians using the sidewalk. Recently there has been a trend toward planting trees back of the sidewalk. This practice has these advantages: (1) when trees are set back the driver has a better view of pedestrians and of cars coming out of driveways and cross streets; (2) the troublesome interference of trees with street lighting is reduced; (3) the objectionable displacement of the curb and sidewalk by growing tree roots is reduced; and (4) there is less interference of trees with the placement of underground utilities and overhead wires.

The recommended minimum width of sidewalk is 4 feet. Total right-of-way width required is 50 feet.

b. **Horizontal Alignment.** Properly designed curving streets offer fewer hazards to traffic than do monotonous straight through streets which encourage high speeds. Curving streets also enhance the appearance of a residential subdivision.

Although a 100-foot radius curve, measured from inside edge of pavement, can be negotiated safely and comfortably at 25 miles per hour, sight distance restrictions such as trees and other obstacles make it desirable that a radius of 200 feet be used as the minimum between intersections so that the actual sight distance for a driver to see pedestrians or children who may be playing in the street will probably be sufficient to enable him to stop within a safe distance in emergencies.

c. **Vertical Alignment.** Ordinarily no grade should exceed 8 to 10 per cent. The maximum that is desirable from a traffic safety standpoint is 6 to 8 per cent, and if steeper grades are found necessary, they should be very short (150 to 200 feet). However, in sections of the country where snow and ice are prevalent, grades exceeding 4 or 5 per cent are objectionable, although terrain may sometimes make them necessary. North-side slopes are particularly dangerous because thawing is slower than on south slopes.

Also important is the rate of change of grade at hillcrests or summits. Abrupt changes in grade should be avoided because of resulting limitations in sight distance. This is particularly important at night when the beam of the car lights goes off into space (and into the eyes of approaching pedestrians and drivers) and the pavement ahead is not well lighted, thus giving the car occupants the feeling that they are going over a precipice. A rate of change of grade of 3 to 4 per cent per hundred feet is the maximum recommended to give at least 100 feet of sight distance at night. (American Association of State Highway Officials Policy on Sight Distance on Highways used for basis.)

d. **Culs-de-sac.** Where a cul-de-sac is used, there should be provided a suitable turn-around at the end so designed as to accommodate turns by the maximum size vehicle which might be expected to use it frequently, such as a fuel oil truck. The larger the radius, the easier the turn-around maneuver becomes. Also, a large radius increases the frontage on the turn-around, thus permitting more desirable lot layouts and frontage widths. The recommended minimum radius of curvature for the outer edge of the pavement is 40 feet, if there is to be no parking within the circle. If there will be any parking a 50-foot radius is necessary to accommodate such vehicles as fuel trucks. A cul-de-sac should not exceed 400 to 500 feet in length. If it is too long the temptation to turn around in the midblock is greatly increased.

Back-arounds, or T-shaped culs-de-sac may be used satisfactorily where lengths do not exceed 300 to 350 feet and where population densities are low.

e. **Pavement Surface.** Any suitable non-skid surfacing material may be used for paving residential streets, provided it will withstand local weather conditions and that it has sufficient strength to carry expected loads without cracking up and so becoming dangerous.

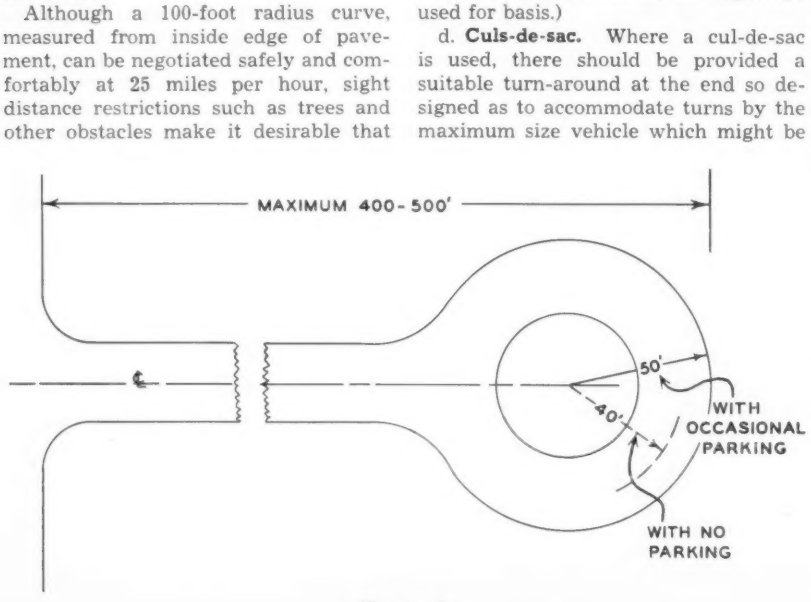

FIGURE 6.
A typical cul-de-sac and turn-around.

2. Local Residential Streets in Multiple-family Developments

Recommendations for horizontal and vertical alignment, culs-de-sac, and surface material for residential streets in multiple-family developments are no different from those in single and two-family developments. The distinguishing feature between the two classes of streets lies in the cross-sectional design, which is, in turn, influenced by the difference in parking requirements and by heavier traffic volumes caused by the greater population density.

a. **Pavement Width.** Two lanes for moving traffic, one in each direction, are usually sufficient to accommodate the volume of traffic in multiple-family developments. Because of the greater amount of occasional curb parking, a six-foot greater width is desirable than was recommended for single and two-family developments. The recommended width between curbs is 32 feet.

There may be instances where it is impossible to provide sufficient off-street parking facilities to meet the demand. Examples are in the improvement or redevelopment of residential areas where faulty original design cannot be easily corrected. Where, for any reason, curb parking must be sanctioned, the street should be of sufficient width to provide for such parking on both sides of the street. This will elimi-

nate half the number of pedestrian crossings by people walking from car to home that would occur if parking were permitted on one side only. Angle parking at the curb is strongly discouraged except on purely local streets where parking bays are provided. Studies have shown that the minimum width for a roadway on which there will be considerable parallel parking on both sides should be 36 feet. In this case the right-of-way should be 60 feet wide. Public Roads Administration studies show that greater traffic capacity results from even small increases in roadway width.

b. **Curbs and Sidewalks.** The discussion of curbs and sidewalks under the subject of residential streets in single and two-family developments is fully applicable here except that different treatment is necessary where parking bays are employed.

DESIGN OF FEEDER STREETS

1. General Considerations

Feeder streets have been defined as streets connecting the local residential street system and the main highway. Of course feeder streets, too, are residential in that they have residences along them.

In planning the requirements for feeder strees, consideration must be given to adjacent development, either existing or proposed. At the outset the developer should investigate, through the planning agency having jurisdiction in the area, the proposed pattern of main and secondary highways. If, in fitting his development to an existing official master street plan, the developer finds that one of his streets is to become a secondary highway at some future date, he should fit that location in as a feeder street of suitable design to serve the added function as a secondary highway. Good planning, however, seeks to avoid having to "split" a residential subdivision with a secondary or main highway, for such high-volume arteries detract from the value and livability of homes fronting on them.

The intersection of the feeder street with the main highway is a rather critical factor in deciding upon the width, in lanes, of the feeder street. With a high percentage of traffic turning onto the main highway, it is difficult for more than one lane to merge with through traffic unless the intersection is given special treatment. There is no need to build a street with a capacity greater than its intersections will handle. Very careful intersection design is warranted so that safe and efficiently operating intersections will result. Often extra land needs to be taken to provide for needed islands, special purpose lanes, etc.

2. Pavement Width

A pavement width of 36 feet is recommended because the feeder street provides access to abutting properties as well as collects traffic from local residential streets. Hence, traffic volumes are greater. This recommendation is also based on the fact that, no matter how adequate off-street parking facilities may be, there will be occasional curb parking and, as stated above, desired freedom of movement on feeder streets cannot be achieved if drivers must weave to avoid such occasional parkers. Moreover, unless the feeder street is considerably wider than the local street it will not attract local street traffic and serve its function as a collector.

3. Curbs and Sidewalks

It is recommended that only straight curb be used on feeder streets because such streets are wider than local residential streets and traffic density will usually be greater. Otherwise the recommendations concerning curbs and sidewalks under "Local Residential Streets in Single-family Dwelling Development," are applicable here.

4. Horizontal Alignment

Recommendations concerning horizontal alignment of local residential streets are applicable here.

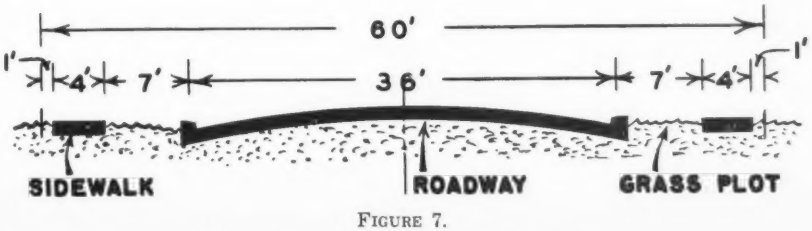

FIGURE 7.
A typical cross-section of a feeder street.

5. Vertical Alignment

See same subject for local residential streets.

6. Pavement Surface

The same surfacing treatment as recommended for local residential streets is suitable for feeder streets.

INTERSECTION DESIGN

1. General Considerations

Design of intersections should receive careful consideration, because this is where a high proportion of motor vehicle accidents occur (about 50 per cent in urban areas). Where the paths of vehicles moving in different directions cross each other, a traffic hazard is inevitable, but by the observance of fundamental principles of traffic design, the frequency of accidents can be greatly reduced. (*See "Subdividing for Traffic Safety" by Harold Marks, Traffic Quarterly, July 1957, or Urban Land, Oct. 1957, Vol. 16, No. 9. Ed.*)

2. Slight Distance at Intersections

Many accidents at uncontrolled intersections are a result of obstructed view between drivers on the intersecting streets, especially if the obstruction to view is deceptive—does not appear serious, but actually is like a low hedge which conceals a vehicle on the cross street in a cut. Such a deficiency is one that is much more easily avoided than corrected because once in existence corrective measures are often difficult and expensive. Corner property owners may not be willing to make changes, for example.

Unless the proper type of traffic control device is installed, an intersection should be so designed and the adjoining property so developed that the driver of a vehicle on one of the streets has an unobstructed view of the entire intersection together with a length of the intersecting street sufficient to enable him to stop his car in time to avoid a collision with a car approaching on the other street. To meet this requirement each vehicle must be visible to the driver of the other vehicle when each is 75 feet from the center of the intersection. This is based on speeds at the intersection being slightly less than 25 mile-per-hour speed assumed for the midblock on local residential streets, a one-second driver reaction time, a comfortable stopping rate, and nearly flat grade. Within the "sight triangle" established by the intersection and two

points 75 feet from it, no building or present or future obstruction should be permitted. (See Figure 8.) Parking must be prohibited at the curb within this sight triangle. The developer can do much to meet this requirement by designing individual lots at corners so as to preclude restrictions to visibility. As a protection for the future, one solution is a restriction in the deed for such corner lots.

In the case of an intersection controlled by stop signs, which often will be the intersection of a feeder street with a main highway, the sight distance should be sufficient for the driver on the main highway to be able to stop before reaching the intersection in case the driver of the car stopped at the STOP sign should decide to cross or turn into the main highway. If the prevailing speed on the main highway is 50 miles per hour, for example, the distance at which a driver on the main street should be able to see a stopped car on a side street would be approximately 166 feet (based on one second reaction time, 50 per cent braking efficiency and a flat grade).

Of equal or perhaps greater importance than trying to get adequate sight distance at an obviously dangerous point is to arrange for the placement of the intersection of a feeder street and a main highway so as to avoid physical obstructions to visibility. Bringing a feeder street onto the main highway at a deep cut, for example, is obviously hazardous.

In a number of states and counties the highway department has control over the location and design of entrances to main highways. When the subdivider takes his plans to the plat approving authority, it is therefore recommended that he assure himself that the plans will be approved by the proper highway authorities. If the subdivision is in an area where there is no plat authority, the developer should go to the county engineer or other appropriate agency which should be in a position to advise on the traffic safety considerations involved in getting subdivision traffic onto a main highway with the least hazard. In some such cases a district engineer of the state highway department may give help.

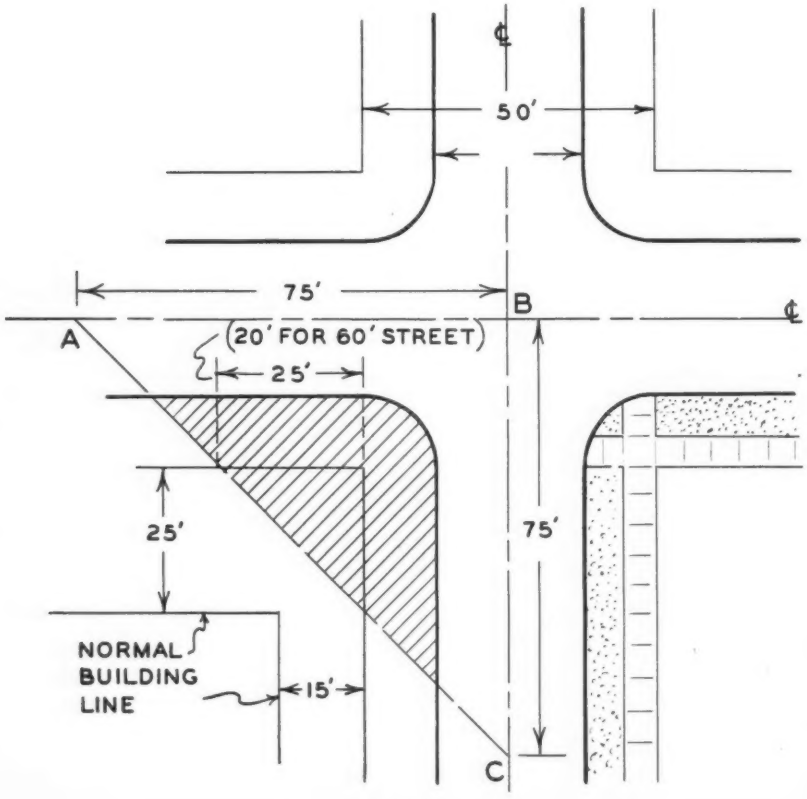

FIGURE 8.
No building or other obstruction should be located within the shaded area. Triangle ABC is referred to as the "Sight triangle."

3. Vertical Alignment at Intersections

Within the intersection the general practice is to provide a flat grade with appropriate drainage slopes. It is highly desirable to carry this flat section back 50 to 100 feet each way from the intersection. Topography does not always permit this, but the grade should be kept as low as possible and not in excess of 3 to 5 per cent on such intersection approaches. Level, or nearly level, intersection approaches are considerable aids to safety by improving conditions for stopping, providing better sight distance, and increasing comfort by eliminating the necessity for constantly applying brakes while waiting, and for starting on upgrades. For example, braking distance from 25 miles per hour with 50 per cent braking efficiency (which is legal in most places) is increased from 42 feet on the level to 46.5 feet on a 5 per cent down-grade. Necessary sight distance should be correspondingly increased under such conditions.

Grades between 100 and 150 feet of an intersection should not exceed 6 per cent. As pointed out, in northern climates where ice conditions are frequent much lower gradients are preferred.

4. Horizontal Alignment at Intersections

In the ordinary operation of a car, streets intersecting at about 90 degrees are the most desirable because each driver can more easily see other cars approaching from both the left and right. Also the problem of keeping physical obstructions out of the "sight triangle" is less complicated at 90-degree intersections.

When the angle of intersection is less than about 60 degrees the accident hazard is considerably increased. The driver must turn his head sharply away from his pathway ahead and his view in so turning is often restricted by parts of the car, other front seat passengers, or by the load in the case of commercial vehicles. Unfortunately, under such circumstances drivers are sometimes prone to take a chance rather than assure themselves that the way is clear.

The curb radius where residential streets intersect should permit right turns by passenger vehicles without

their mounting the curb or crossing over the center line. A 12-foot radius of curvature for the curb at the corner is the minimum that will adequately meet this requirement. The curb radius should not be greatly increased because large radii encourage too high speed in turning and increase both distance and hazard for pedestrian crossings.

Where a feeder street intersects a main highway, curb radii must be increased to 50 feet to allow trucks and buses to make right turns and remain in their proper lane without encroaching upon high speed traffic lanes on multi-lane highways or across the center line of two-lane main highways. A right turn cut-off lane of fairly large radius, with a triangular island beyond (see figure 10) has the advantage of providing more pedestrian protection while still taking care of the turning needs for the larger vehicles. An acceleration lane on the main highway is desirable.

FIGURE 10.
Note right-turn cutoff lane allows continuous movement.

SIDEWALKS

Traffic safety demands good sidewalks on each side of every residential street. Vehicular traffic and pedestrians should be segregated. It is unsafe, unreasonable and often disagreeable to pedestrians to be forced to walk on the paved roadway. Parents do not want children playing in the roadway—yet if they have roller skates, scooters or other wheeled toys, they will use the roadway unless a smooth sidewalk is available. Mothers with baby carriages and elderly persons should have sidewalks. Nearly three-fifths of the persons killed in traffic are killed at night, and walking on the roadway is a major night hazard. In numerous places state or county highway authorities have become so impressed with their need that they are building extensive mileages of highway sidewalks. How inappropriate it would be for new residential developments not to provide them.

There may be places, as in estate-type developments, where a sidewalk only on one side, or even no sidewalks, can be justified, but this should be a very rare exception.

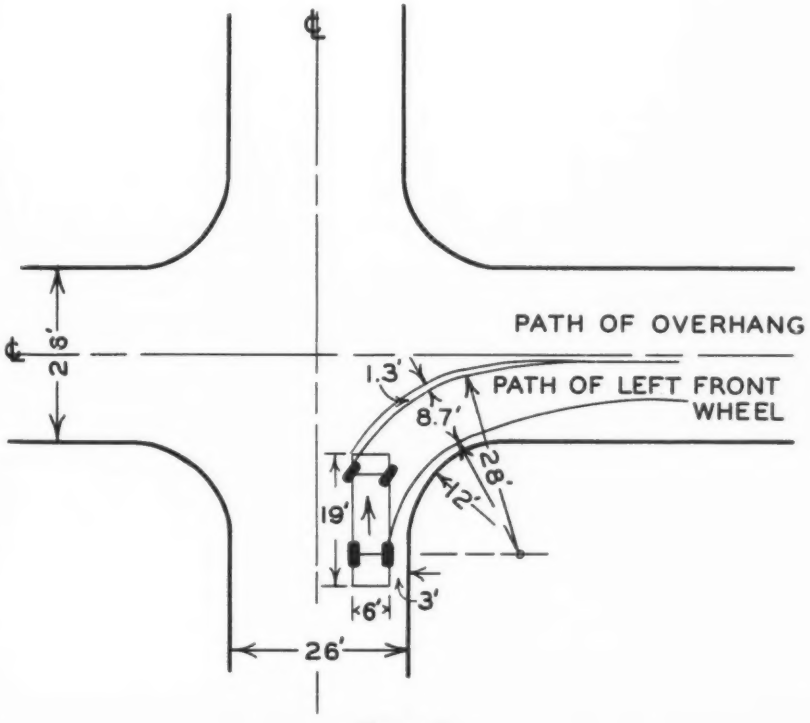

FIGURE 9.
Establishing minimum curb radius at intersecting local residential streets using A.A.S.H.O. design passenger vehicle.

1. Placement

The general consensus among those contributing to this report was against the placement of the sidewalk next to the curb, but there was not complete agreement. It was generally agreed, however, that the sidewalk should never be placed adjacent to a roll curb or adjacent to any curb on a feeder street. In other words, the sidewalk

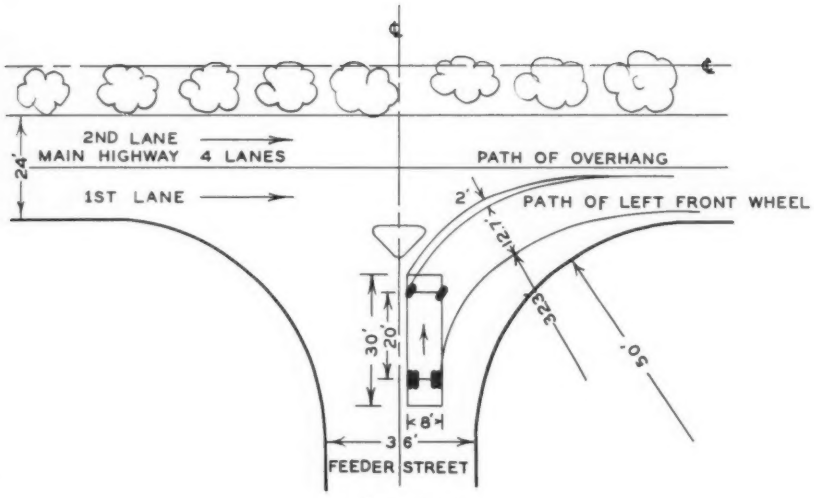

FIGURE 11.

Establishing minimum curb radius at intersection of feeder street within a main highway using A.A.S.H.O. design truck or bus.

should not be placed next to the curb anywhere except on a local residential street with straight curb—and even this had no strong support from the traffic standpoint.

Most technicians favored the recommendation that sidewalks be set back from the curb at least 3 feet, and if trees were planted in the strip the set-back should be at least 7 feet. Advantages of setting the sidewalk back from the curb 3 feet or more include: (1) There is space to pile snow removed from the roadway or sidewalk; (2) Pedestrians are not as likely to be "splashed" by passing cars; (3) There is a "safer" distance between the moving vehicle and the pedestrian; (4) Children are less likely to ride wheeled toys into the roadway over an "insulation" strip; (5) There is space for placing fire hydrants, utility poles and street signs outside of the sidewalk area.

2. Width

Minimum sidewalk width of 4 feet is recommended for the average subdivision street, although it may be necessary on feeder streets in the vicinity of shopping centers, schools and recreation areas to increase this to 4½ or 5 feet. Sidewalks wider than needed increase costs and reduce space for other cross-sectional design features.

PARKING IN RESIDENTIAL AREAS

As a general policy, parking facilities should be provided off the street in sufficient number for vehicles of persons residing in the development. Provision of parking at the curb is costly. Also curb parking is not advisable because a less expensive foundation can be used for parking only and also a less expensive surface is feasible. Many pedestrian injuries and fatalities occur as a result of stepping into the street from between parked cars, and visibility is restricted when there is curb parking.

The provision of parking off the street, as a policy, can be put into effect by (1) voluntary action through design by the developer; (2) subdivision regulations; (3) zoning regulations; and (4) private covenants. Some guiding principles as set forth in paragraphs which follow should prove of value irrespective of the method of putting them into practice.

It is generally accepted that for single-family dwellings there should be provided a minimum of one off-street parking space per family unit. The same should apply to semi-detached dwellings. For multiple dwellings a study of zoning regulations, where in effect, shows that the requirement is for less parking than for single-family and semi-detached dwellings. The average of 33 zoning ordinances was one space for each 1½ family units. The range was from one space per family unit to one space for five family units. Such requirements will vary with the location of the development, economic status of occupants, density of occupancy, and nearness to shopping, recreation and similar facilities. (*The great increase in "two-car" families since this report was prepared, particularly in single-family areas, suggests substantially higher ratios for off-street parking than those mentioned above. Zoning requirements of two off-street spaces are becoming quite common—in one case three—while one space per unit plus a percentage for guest parking is being specified in outlying multi-family development. Ed.*)

Types of Facilities

(1) Private garage or parking space should be provided for single and semi-detached dwellings on the same lot with the dwelling and with access by private driveway. Residential driveways are discussed later.

(2) Parking bays not physically divided from the roadway (as illustrated in Figure 12) should be used only where streets carry no through traffic and where traffic volumes are not large, as on local streets serving a moderate number of families. Their principal advantage is that the parking space is placed where it will be used. They are also less costly to provide than other types of parking facilities since roadway space is used for maneuvering. The over-all space requirement per car

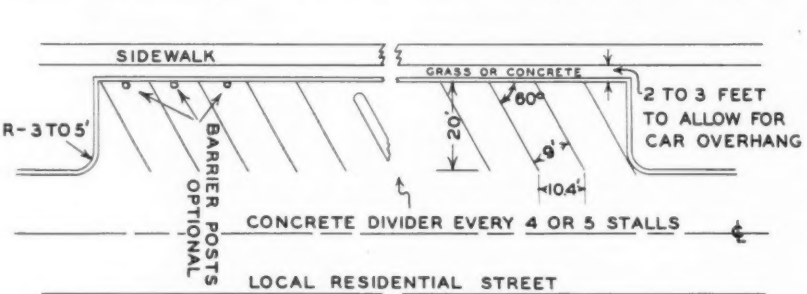

FIGURE 12.

A typical parking bay on a local residential street.

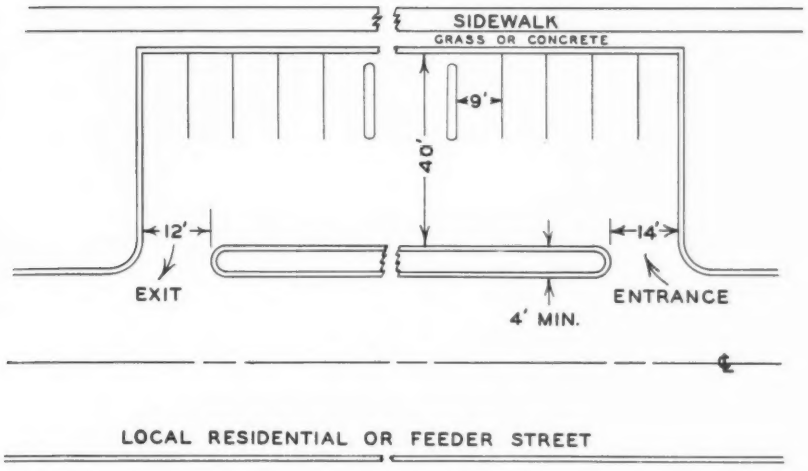

FIGURE 13.

A typical enclosed parking bay, sometimes called a parking "harbor."

is approximately 210 square feet with stalls 9 feet wide and 20 feet deep and with 60° angle parking. With 90° parking, the space requirement would be 180 square feet per car, but getting into and out of stalls would be more difficult. Space for parking should be entirely off the traveled portion of the roadway and on the building side of the normal curb line. Sidewalks should be set back from the curb of the parking bay to allow for car overhang—from two to three feet in addition to the normal sidewalk width will be adequate. Most of the committee favored paving this set-back strip. Straight curb should be used to prevent parking from extending onto the sidewalk.

The parking bay has its most practical application in the case of row houses where individual drives are not feasible and there is no rear court or alley, and for apartment developments of low density fronting on local streets. The parking bay is not ordinarily acceptable, desirable or practicable where homes are individually owned. One obvious reason is that cars would have to be parked too far from some homes.

(3) Parking bays physically divided from the roadway, usually by a sidewalk or planting strip (see Figure 13) with adequate maneuvering space also off the roadway, are desirable where there is or will be a greater amount of traffic on the street than in cases where the open bay is appropriate. In general, the enclosed bay is desirable on feeder streets. This type of parking bay, sometimes known as a "parking harbor," requires approximately 360 square feet per car including entrance, exit, physical barrier and maneuvering space. Its principal advantage is that there is much less hazard involved in backing out from a parking stall than in the case of the open bay, since all maneuvering space is off the traveled portion of the roadway. Also, the enclosed bay imposes no delay to moving traffic on the street except at established entrances and exits. There is, however, danger of children using the maneuvering area for play.

Stalls in parking bays should be marked either with painted lines or permanent markers to encourage parking at the design angle. A permanent, raised strip between every fourth or fifth stall will serve the purpose quite well. 90° parking is illustrated in Figure 13. Angle parking may be used.

(4) The parking lot or compound probably offers the most desirable off-street parking in connection with multi-family developments. It should be so located that residents need not walk more than 150 feet from lot to dwelling, for unless such off-street areas are made convenient and readily usable many drivers will park on the street and defeat the purpose of the off-street parking space. It should not be necessary to cross streets while walking between the parking lot and dwelling. The area should be surfaced, stalls permanently marked, and entrance and exit should be separate and clearly designated. It is preferable that entrance and exit be on opposite ends of the lot and that all traffic move one way, but physical layout may not always permit. Single-lane entrances should be at least 14 feet wide, exits 12 feet wide. On small lots, say 20 to 25 cars, a 14-foot opening can serve for both entrance and exit. Land area required is 275 to 300 square feet per car including adequate aisles and maneuvering space.

Parking lots should not be located near play areas unless fences or other suitable barriers are installed around the lots or around the play areas.

One of the most troublesome parking problems in connection with residential developments is how to provide for service vehicles and visitors' cars.

As a practical matter, service vehicles, such as milk wagons and vehicles of meter readers, utility and other repair men, will be parked on the street unless service entrances, utility connections and off-street parking facilities are so located as to encourage parking off the street.

As a general policy, service vehicles which normally remain parked for periods longer than a few minutes should be permitted and encouraged to park in the space provided for residents. Only in rare instances would all parking spaces be filled during times when service-vehicle parking was needed.

At this writing there are no established standards or available facts with regard to the amount of parking which should be provided for the cars of visitors. Certainly it would not be economically sound or feasible to provide for the relatively rare need occasioned by a wedding, funeral, or other sizeable gathering. In fact, in such cases arrangements should be made with local authorities to have police supervision of traffic and parking, if conditions warrant.

Probably the most practical course to follow is (1) in the case of the individual and semi-detached dwelling to allow no additional space for visitors' cars on the assumption that private driveways will handle the need in a high majority of cases, and (2) in the case of multi-family dwellings to take into full consideration such factors as car ownership and availability and attractiveness of public transportation, make a liberal provision for the parking of residents' cars, and expect visitors to park in the same facilities as provided for residents. One car space per family will leave a few spaces for visitors under most circumstances. (*See previous Editor's note on recent trends in off-street parking.*)

ALLEYS

Alleys in modern single or two-family residential developments are no longer considered necessary or desirable. However, in row house or other multi-family developments, alleys or rear service drives may be necessary not only for refuse collection, but to provide access for garages, other off-street parking facilities, and for fire protection. Rear access to stores in shopping center areas should always be provided for loading and unloading purposes. If provided, alleys should be 20 feet wide and be paved for the entire width. A lesser width makes them inadequate for passing, backing, and for commercial vehicles. Greater width encourages their use for parking and even for some traffic movement. Alleys should normally enter streets at right angles. Dead-end alleys are not desirable unless an adequate turn-around is provided.

CURB CUTS FOR DRIVEWAYS

Where rolled curbs are used, no curb cuts are required. However, it is desirable to flare the driveway paving somewhat where it meets the curb to provide for turning movements. This flare should have the same 3 to 5-foot radius as used at curb returns.

Where the straight curb is used, curb cuts and driveway aprons are necessary for entrances to garages and parking areas. For the single-family home a driveway 8 feet wide is advisable with curb returns at the roadway of 3 to 5 feet in radius. With a 26-foot roadway, this will permit a car to enter the roadway without being obstructed by a car parked at the opposite curb. Considering the amount of traffic on local residential streets it is neither practical nor necessary to attempt to confine the movements of cars entering or leaving driveways to one-half of the roadway. However, on feeder streets where there will be more traffic, cars entering the roadway from driveways should be able to do so without crossing the roadway center line. This can be accomplished with the same 3- to 5-foot curb radii as used on local streets if the feeder street has a 36-foot roadway as recommended where there is parking.

In higher density multi-family developments where parking bays or compounds are used which entail more car movements, a somewhat greater driveway width and curb radius should be provided. In most cases it will be advisable to use curb returns and aprons rather than the rolled curb in order better to control entrance and exit movements, especially if the compound is a large one. The radii of curb cuts at such driveways should ordinarily not exceed 7 feet. To avoid interference with both pedestrian and vehicular traffic on the cross street, it is recommended that driveways be located at least 40 feet away from the corner of the lot nearest the intersection. This can be done on a lot of 50 feet or more in width.

Where hard surfacing is used on driveways and parking areas, it is desirable to keep the area relatively level, consistent with drainage requirements, in order to discourage its use as an incline by children for roller skating or coasting.

Driveway aprons should provide an easy transition between roadway and driveway, with no sharp dips or sudden changes in grade. This is particularly essential in view of the long overhang and low ground clearance on many models of passenger cars. Scraping and dragging of rear bumpers and exhaust tailpipes at driveway entrances is not an uncommon experience. (See Figure 14.) (*This is even more true today, except for the "compact." Ed.*)

Entrances should be designed to accommodate the "worst" condition of combined long rear overhang and low bumper or tailpipe clearance—approximately 4½ to 5 feet in the case of rear overhang, and just over 6 inches for tailpipe clearance. (Most rear overhang distances are about 4 feet and minimum ground clearances at the rear about 9 inches.) Thus, considering possible overloading and "bouncing" effect, a change of grade not exceeding one inch per foot within any 10 feet of distance will provide ample clearance for almost all cars.

FIGURE 14.
Long car overhang and low clearance make driveway apron design especially important.

SELECTED REFERENCES

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Play Yards Are Life Savers. 1954. American Automobile Association, 1712 G St., N. W., Washington 6, D. C.

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